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Using satellite data to estimate the conditions for formation of secondary aerosol particles and sulphuric acid concentrations

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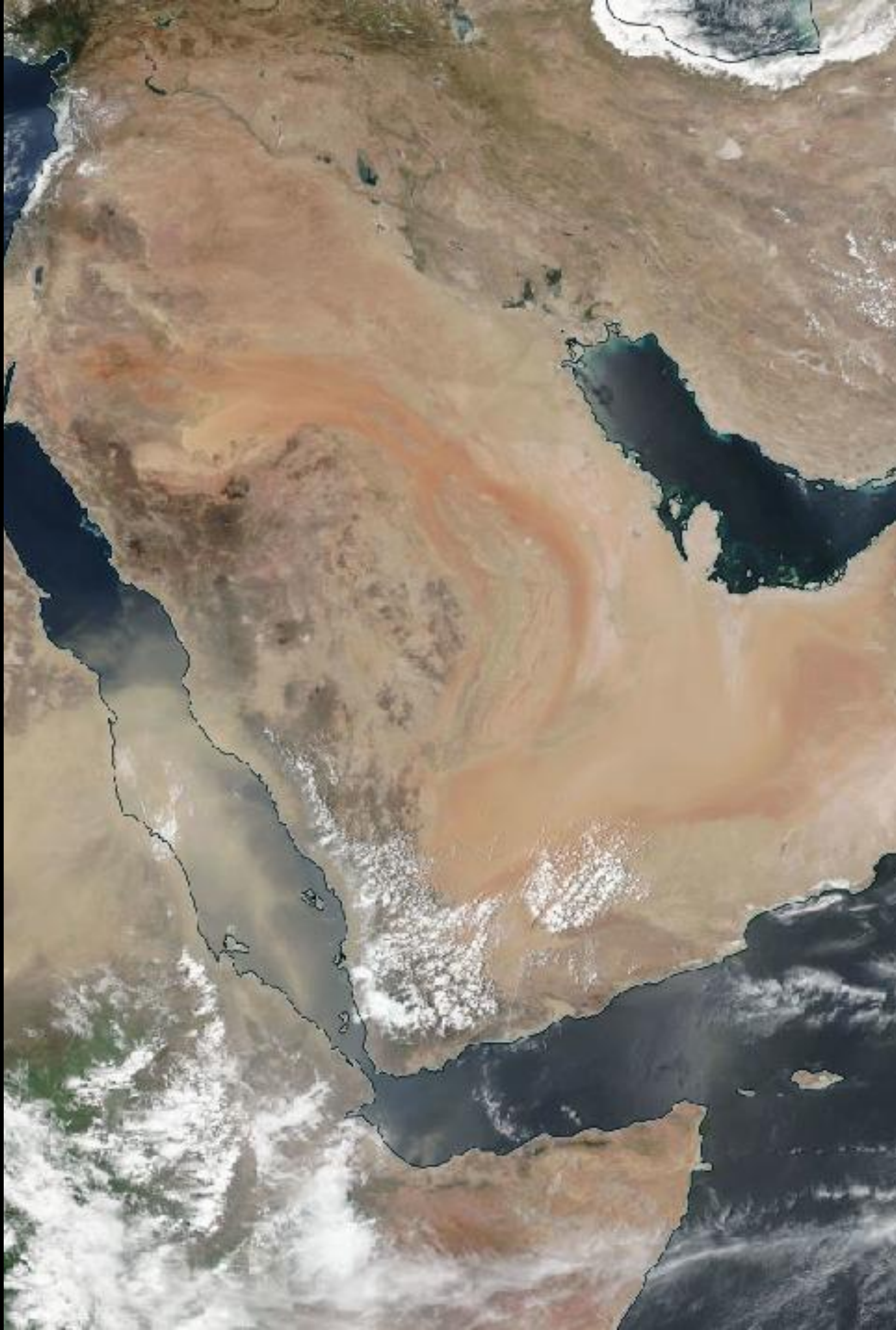

Background

Formation of Secondary Aerosols

Precursors + UV radiation + existing aerosols	Formation processes	Concentrations
NO_2 SO_2 NH_3 H_2O AOD Photolysis rates	New particle formation →	→ **Secondary aerosol particles**

Global multi-year satellite observations available

↔

Observation with satellites not possible

The potential of satellite data?

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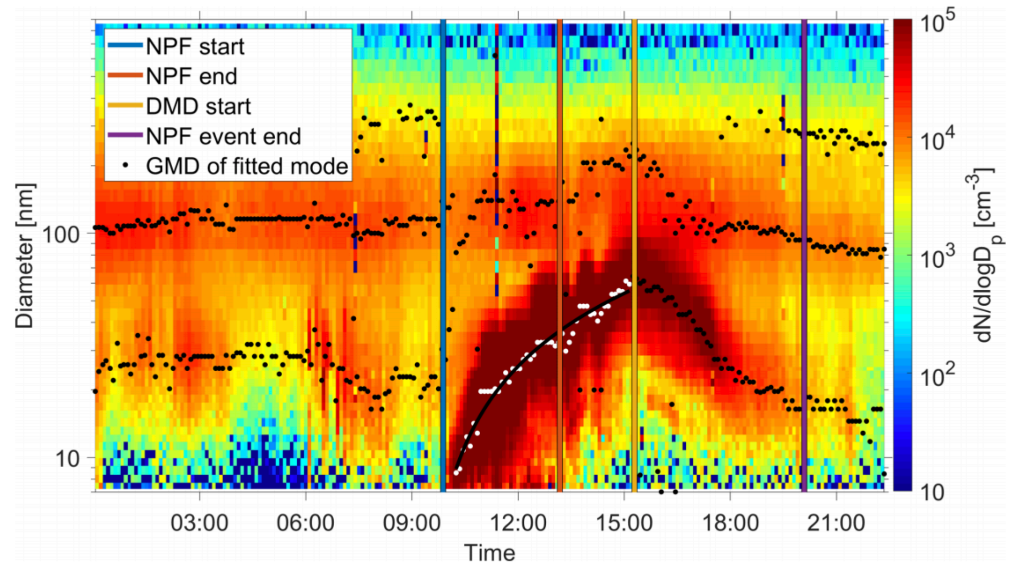
New particle formation, growth and apparent shrinkage at a rural background site in western Saudi Arabia

Hakala, S. et al.

- Aerosol measurement campaign by FMI and Univ. Helsinki at rural background site, Hada al Sham, western Saudi Arabia during 2013-2015
- The main goal of the campaign was to study formation of secondary aerosol particles.
- Observations showed frequent new particle formation: in 73% of all analyzed days (454) new particle formation event was observed



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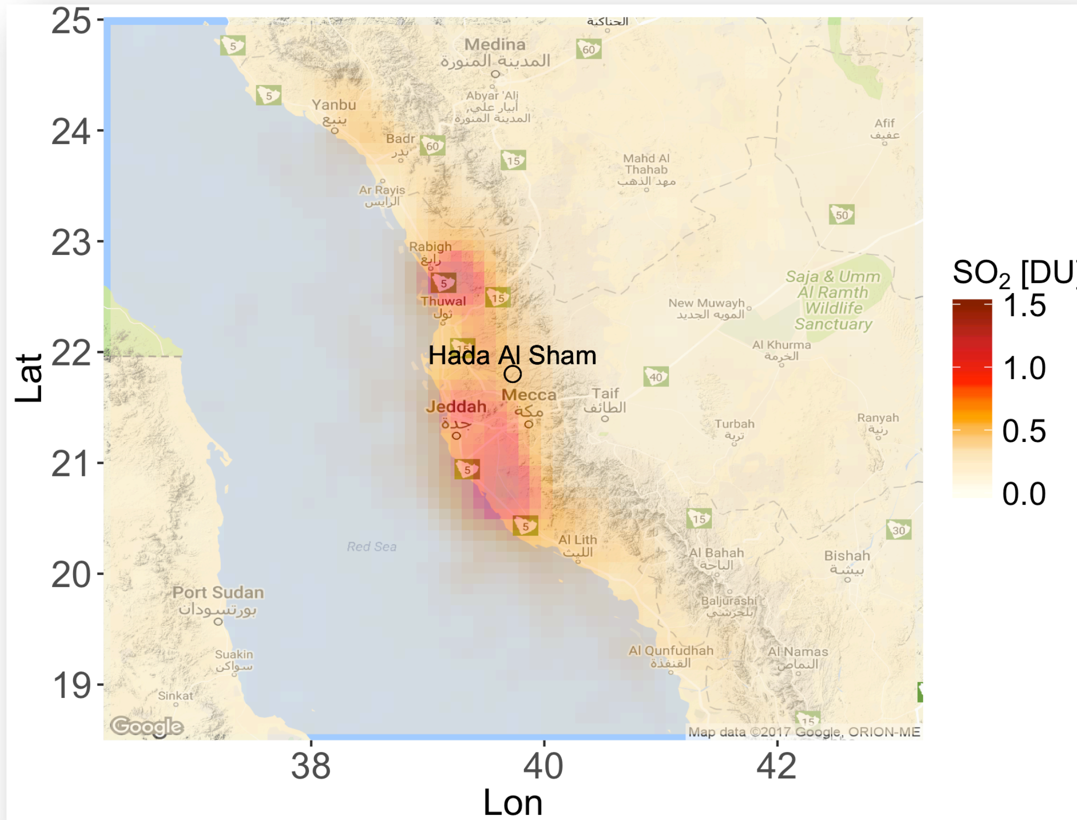
- During the campaign only aerosol properties were measured.
- SO_2 and its oxidation through radical reactions to sulphuric acid (H_2SO_4) act as a major contributor to new particle formation
- OMI observations were used to analyze the trans-port of anthropogenic pollution and the contri-bution of SO_2 and to the NPF events.

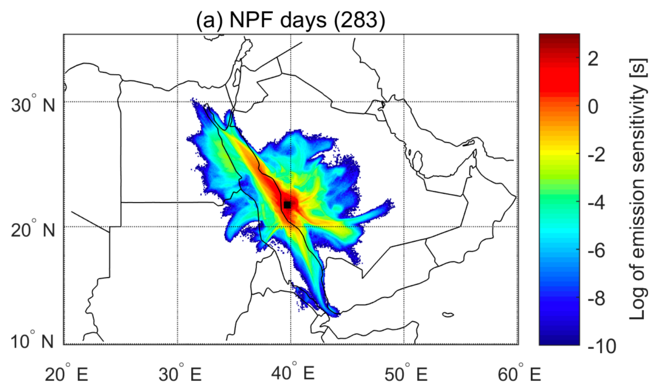
Mean OMI PBL SO2 during the measurement campaign 2013-2015



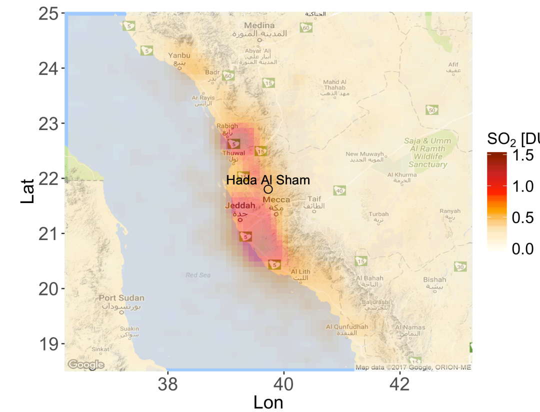
Main findings of the campaign

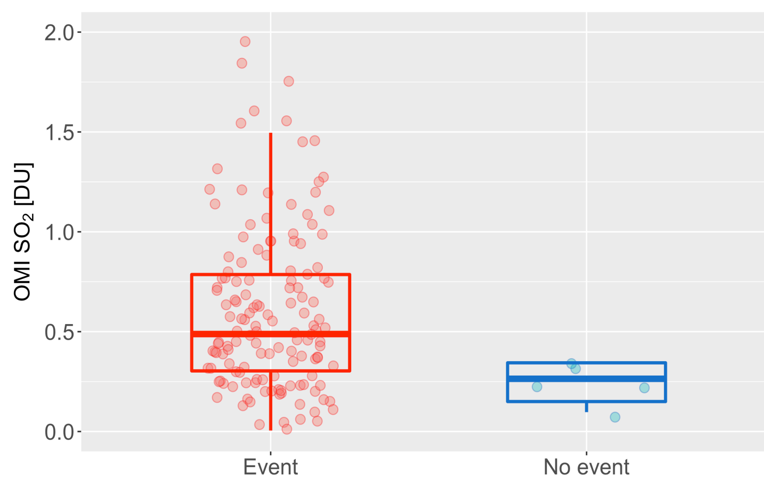
- Exceptionally high NPF frequency is likely explained by the high production precursor vapors, especially sulfuric acid, in the transported emission plumes from the coastal cities and industrial areas.

Air mass analysis on NPF days



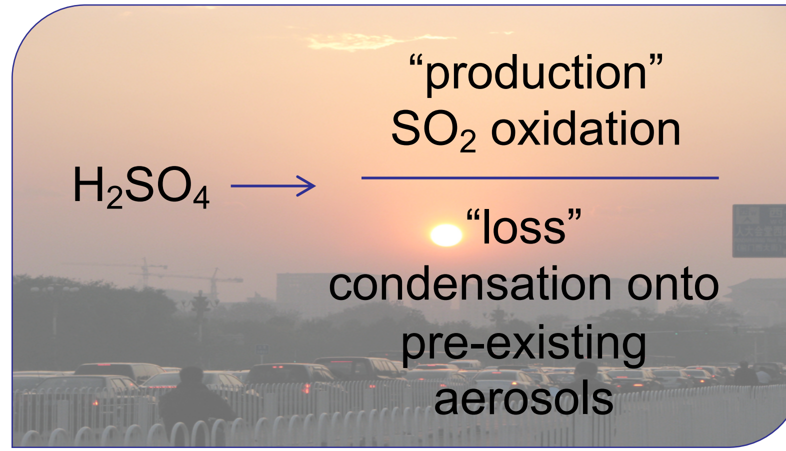
OMI SO_2 on NPF days





Proxies for estimating sulphuric acid concentrations

- H_2SO_4 act as a major contributor to new particle formation and subsequent growth of the freshly formed particles
- Gaseous H_2SO_4 is very challenging to measure due to its typically low concentrations in the troposphere
- Currently in situ observations of H_2SO_4 are available only for a few locations with very limited temporal coverage
- To overcome the issue, proxies for H_2SO_4 have been developed using in situ data



Examples of situ proxies-based for H_2SO_4

Table 5. Nonlinear proxies.

Proxy	Equation
N1	$a \cdot k \cdot \text{Radiation}^b \cdot [SO_2]^c \cdot CS^d$
N2	$a \cdot k \cdot \text{Radiation}^b \cdot [SO_2]^c$
N3	$a \cdot k \cdot \text{Radiation}^b \cdot [SO_2]^c \cdot RH^e$
N4	$a \cdot k \cdot \text{Radiation}^b \cdot [SO_2]^c \cdot CS^d \cdot RH^e$
N5	$a \cdot k \cdot \text{Radiation}^b \cdot [SO_2]^c \cdot (CS \cdot RH)^f$

Mikkonen et al., ACP, 2011

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How about using satellite observations for proxies?

Potential satellite observations for H_2SO_4-proxy

Production: SO_2 H_2O $J(O_3)$ / UV

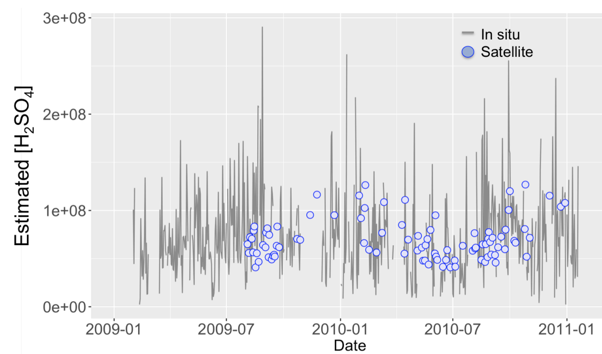
Loss: AOD

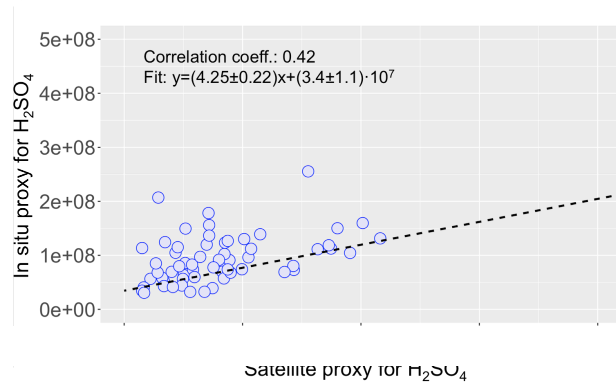
- Preliminary results indicate that one of the main difficulties is to describe the "loss"-term

Preliminary tests: Elandsfontein, South Africa

"simplified proxy" from Mikkonen et al., 2011:

$$[H_2SO_4] = 1.86 \cdot 10^{-1} \cdot k \cdot radiation \cdot [SO_2]^{0.5}$$





Summary

- OMI (PBL) SO_2 observations have been used in aerosol measurement campaign to study new particle formation events
- OMI observations support the conclusion that frequent new particle formation events are related to high production precursor vapors.
- Next steps include the development of satellite-based proxies to estimate sulphuric acid concentrations
- New collaboration, new ideas, new applications (e.g. for surface UV-observations)!